

On the origin of the organic-rich material on Ceres

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The detection of localized, organic-rich material on Ceres [1] poses an interesting conundrum. Either the organic-rich material has an exogenous origin, and thus it has been delivered to Ceres after its formation; or it has an endogenous origin, and thus it has been synthesized and/or concentrated in a specific location on Ceres via internal processes.

Both scenarios have shortfalls, indicating we may ultimately be misunderstanding how organic matter has been formed, transported and reworked in solar system objects. The very location of Ceres at the boundary between the inner and outer solar system, and its intriguing composition characterized by clays, sodium- and ammonium-carbonates [2], suggest Ceres experienced a very complex chemical evolution. The role of organics in this evolution is not fully understood, with important astrobiological implications [3].

Here we investigate the viability of delivery of organics to Ceres via asteroidal/cometary impactors. We will present iSALE shock physics code [4-5] simulations that explore a range of impact parameters, such as impactor sizes and velocities, and discuss the likelihood of organics delivery. We find that comet-like projectiles, with relatively high impact velocities, are expected to lose almost all of their organics due to shock compression. Asteroidal-like impactors, with lower incident velocities, can retain 20-30% of their pre-impact organic material during delivery, especially for small impactors and very oblique impact angles. However, the spatial distribution of organics on Ceres seems difficult to reconcile with delivery from small main belt asteroids. These findings corroborate an endogenous origin for the organics on Ceres.

- [1] De Sanctis M. C. et al. *Science* 355, 2016. [2] De Sanctis M. C. et al. *Nature* 536, 2016. [3] Castillo-Rogez J. C. et al. *Planetary Science Vision 2050 Workshop 2017* (LPI Contrib. No. 1989). [4] Amsden A. et al. *LANL Report*, LA-8095, 1980. [5] Collins G. S. et al. *MAPS* 39, 2004.